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Food Habits of Lesser Scaup *Aythya affinis* Occupying Baitfish Aquaculture Facilities in Arkansas

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Abstract.—Lesser scaup *Aythya affinis*, medium-sized black and white diving ducks, were collected at Arkansas baitfish farms during November–December 1999 (N = 33), January–February 2000 (N = 39), and March–April 2000 (N = 22) to determine seasonal differences in their diet and their relative impact to baitfish production. The mass of gastrointestinal contents was used to determine the proportion of each diet item relative to all items recovered during stomach analyses. Chironomids were the primary food item recovered. Ten of 94 (10.6%) scaup contained identifiable fish biomass. Fish bones and otoliths were found in an additional 14 scaup (14.9%). All fish remains were identified (via otoliths) as those commonly produced at Arkansas baitfish farms (Cyprinidae). Other diet items (ranked by proportional mass) were vegetative seeds, snails, insects, crayfish, and other aquatic worms (class Oligochaeta). Scaup diets were similar among collection periods, between males and females, and between juvenile and mature ducks. We estimated the economic impact of lesser scaup to baitfish production based upon estimated duration of ducks at farms, the proportion of ducks containing fish, and scaup energetic requirements. Provided estimates of scaup abundance and the cost of bird harassment at a particular farm, economic thresholds (i.e., fish replacement cost as a function of scaup predation) will facilitate cost-effective decisions regarding bird damage management at Arkansas baitfish aquaculture facilities.

Arkansas has the largest baitfish aquaculture industry in the United States, encompassing 11,250 ha of production in 1998 (Collins and Stone 1999). Although baitfish aquaculture exists throughout Arkansas, the production of golden shiners *Notemigonus crysoleucas*, goldfish *Carassius auratus*, and fathead minnows *Pimephales promelas* is located primarily in central Arkansas, east of Little Rock (Lonoke and Prairie counties). Most Arkansas baitfish acreage occurs along the Mississippi flyway where these facilities are occupied by many species of waterbirds.

Although much research has substantiated the existing or potential impacts to North American aquaculture from herons, egrets, pelicans, and cormorants (Stickley et al. 1992; Glahn and Brugger 1995; Stickley et al. 1995; Wywialowski 1999; King and Werner 2001; Werner et al. 2001; Glahn and Dorr 2002; Glahn et al. 2002), there is a paucity of information regarding the impacts of diving ducks (e.g., bluebill or lesser scaup *Aythya affinis*) on baitfish production. Philipp and Hoy (1997) reported that 45 of 223 scaup (20%) collected at Arkansas baitfish facilities (in March 1995, and from December 1995 to March 1996) contained baitfish. These authors estimated that the replacement cost of golden shiners and goldfish consumed per scaup foraging bout was \$0.04 and \$0.12, respectively, based upon scaup abundance and consumption rate, and baitfish market values.

Afton et al. (1991) suggested that fish comprised 3.5% of lesser scaup diets. C. Custer (United States Geological Survey, personal communication) has also observed scaup feeding on fish in the tailwaters of hydroelectric dams when all other water was iced over. Most studies have not observed piscivory among lesser scaup (Cronan 1957; Harmon 1962; Rogers and Korschgen 1966; Bartonek and Hickey 1969; Dirschl 1969; Bartonek and Murdy

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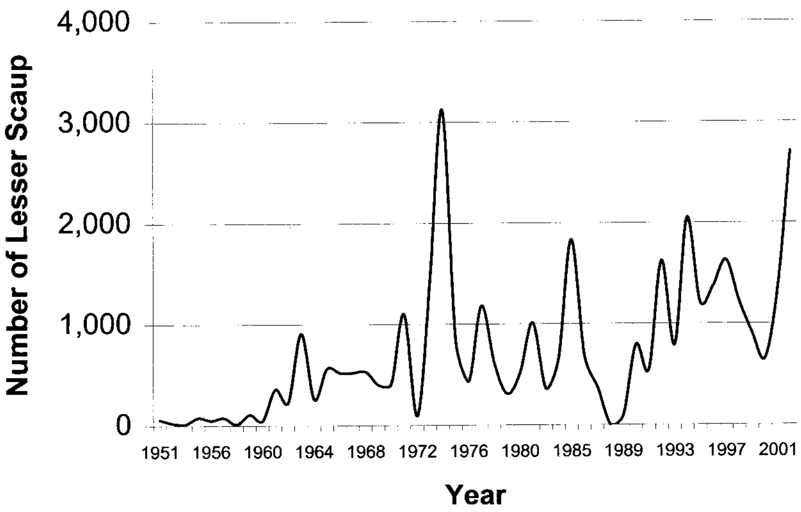

FIGURE 1. *Relative abundance (density within observation circles, 24-km diameter) of lesser scaup in Lonoke, Arkansas, from winter 1951–1952 through 2002–2003 based upon the Audubon Christmas Bird Count (National Audubon Society 2003).*

1970; Kerwin and Webb 1971; Chabreck and Takagi 1985; Hoppe et al. 1986; Afton and Hier 1991; Mitchell and Carlson 1993; Moore et al. 1998; Lindeman and Clark 1999). Rather, amphipods, chironomids, leeches, aquatic plant seeds, and mollusks are the predominant food constituents of adult lesser scaup (Bartonek and Hickey 1969; Dirschl 1969; Bartonek and Murdy 1970; Afton and Hier 1991).

Baitfish aquaculture ponds are stocked at high densities and represent an abundant and easily accessible food source for piscivorous birds. Although many baitfish farmers believe that scaup consume baitfish at their farms, biological and economic information is needed to make reasonable decisions regarding bird damage management at these farms. This study was designed to provide such information by evaluating scaup diets at baitfish aquaculture facilities.

Although the North American breeding population of lesser scaup has declined over the last 20 yr (Austin et al. 2000; Afton and Anderson 2001), local population increases have also been observed. For example, the abundance of lesser scaup wintering near the primary baitfish aquaculture area of Arkansas has generally increased in the last decade (National Audubon Society 2003; Fig. 1). In the absence of regular and systematic counts of lesser scaup occupying Arkansas baitfish farms, we present economic thresholds useful for evaluating the cost effectiveness of scaup damage management at a particular baitfish aquaculture facility.

Materials and Methods

Ninety-four lesser scaup were collected at ten baitfish farms in central and northeastern Arkansas from November 1999 though April 2000 (Lonoke, Prairie, and Greene counties). No effort was made to collect actively foraging ducks. Rather, the primary criterion for collecting a particular scaup was its presence on a baitfish pond. Scaup were collected (using shotguns and steel shot) during each of three collection periods: November–December (N = 33 scaup among 11 d and five farms), January–February (N = 39 among 13 d and seven farms), and March–April (N = 22 among 5 d and three farms). All specimens were collected after 0930 h, since we observed heightened feeding activity by scaup from daylight through early afternoon.

We recorded the date, farm name and location, and county associated with scaup collections, and the body mass (± 0.1 g), age class (juvenile, mature), and gender of collected birds. Wet mass (± 0.01 g) of food items was used for analyses since the goal of this study was to determine impacts to baitfish production. Contents from the digestive tract above the gizzard were removed from each bird, weighed, and washed through U.S. standard sieves to concentrate contents. Gizzard contents were included in the sieved sample but were not weighed. Sieved contents were preserved in 70% ethanol for subsequent microscopy and taxonomic identification. Mass was used to determine the proportion of the diet that was attributable to each prey item. Scaup containing only bony fish parts were not used in proportioning the average mass of consumed baitfish per bird. Recovered fish otoliths were used to identify the species of fish consumed, but were not used to estimate prey biomass.

Previous investigators have hypothesized that the diets of lesser scaup differ between male and female ducks and among various reproductive stages during migration (Afton et al. 1991) and the breeding season (Afton and Hier 1991). Descriptive statistics (average ± SEM) were used to summarize the average percentage of prey items recovered among collection periods, between male and female scaup, and between juvenile and mature birds collected during winter. Descriptive statistics were also used to characterize differences (i.e., males vs. females) in the mass of collected scaup and the mass of fish recovered during stomach analyses. The average mass of recovered fish was used to predict the economic impacts of lesser scaup foraging at Arkansas baitfish farms. The SEM of this parameter estimate (i.e., daily baitfish intake per scaup) was used to estimate baitfish replacement costs. Our economic predictions were further based upon the estimated duration of diving ducks at these farms and the current market value for cultured baitfish.

Results

Diet Analysis

The average body mass of male lesser scaup collected at baitfish farms (N = 63) was 765.4 g (SEM = 10.2, range = 575.6–909.3 g). The average mass of female scaup (N = 31) was 708.5 g (SEM = 12.6, range = 557.8–889.3 g). Although scaup body mass varies seasonally, the average mass of these scaup were within ranges reported by Palmer (1976), Bellrose (1980), and Austin et al. (1998). The stomachs of eight scaup contained no discernable prey items. Most ducks contained one (N = 30) or two (N = 29) prey items. Twenty-one stomachs contained three prey items, and six stomachs contained four items. Ten of 94 scaup (10.6%) contained fish biomass (i.e., muscle, skin). Twenty-six percent of scaup showed evidence of fish consumption, though over half of these birds (15%) contained only remains such as bones and/or otoliths that were not related to biomass. All fish remains were identified as fishes commonly produced at baitfish aquaculture facilities (i.e., Cyprinidae).

Among samples that contained a particular prey item, we recovered an average of 2.27 g of fish (N = 10), 2.10 g of chironomids (N = 39), and 1.57 g of crayfish (N = 6). The mass of other prey items averaged less than 1.00 g among collected ducks. The average mass of prey items among scaup that contained at least one item (N = 86) was 2.13 g/duck (SEM = 0.23, range = 0.10–9.65 g). Chironomids were the primary food item recovered during food habits analyses (by average diet proportion; Fig. 2). Other diet items (ranked by proportional mass) were vegetative seeds, snails, insects, fish, crayfish, and aquatic worms (class Oligochaeta).

Scaup diets were similar among collection periods (Table 1). We observed more chironomids among scaup collected in January–February than those collected in March–April. We recovered more cyprinid fish from birds collected in November–De-

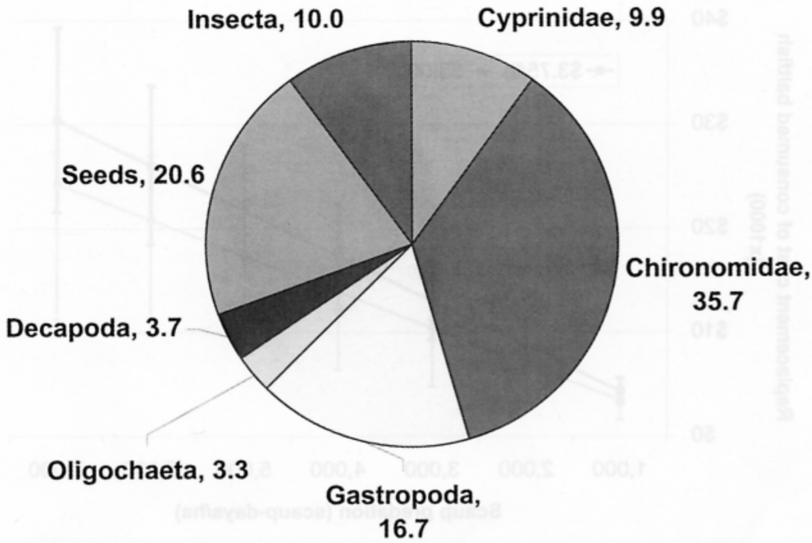

FIGURE 2. *Average percentage (by mass) of prey items recovered from stomachs of lesser scaup* (N = *86) collected at Arkansas baitfish farms from November 1999 through April 2000.*

cember than those collected in January–February. We recovered no crayfish (decapods) from birds collected in March–April. Relative to other collection periods, scaup collected in March–April contained most insects. Similarly, birds collected in January–February and November–December contained most oligochaets and seeds, respectively (Table 1).

The average mass of fish in the stomachs of male (N = 6) and female (N = 4) scaup that contained fish biomass was 1.89 g (SEM = 0.89) and 2.84 g (SEM = 1.05), respectively. Although the diets of male and female scaup were similar, more insects and oligochaets were found in the stomachs of males vs. females (Table 1). We also observed few differences in the diets of juvenile vs. mature scaup (Table 1).

Economic Impacts

We estimated the economic impact of lesser scaup depredation at Arkansas baitfish farms based upon: 1) the number of days that diving ducks are present at these farms; 2) the proportion of scaup that con-

TABLE 1. *Comparisons among average (± SEM) percentages of prey items (by mass) recovered from lesser scaup collected from November 1999 through April 2000 at Arkansas baitfish farms.*

Comparison	Chironomida	Cyprinidae	Decapoda	Gastropoda	Insecta	Oligochaeta	Seeds	N
Collection period								
Nov–Dec	18.2 ± 5.4	11.7 ± 4.7	2.2 ± 1.4	8.8 ± 2.9	1.8 ± 0.9	0.7 ± 0.5	20.2 ± 3.9	33
Jan–Feb	27.0 ± 4.4	1.3 ± 1.3	3.4 ± 1.9	10.5 ± 2.9	4.0 ± 1.5	3.6 ± 1.5	9.6 ± 3.0	39
Mar–Apr	14.5 ± 5.2	5.2 ± 4.3	0.0 ± 0.0	10.0 ± 3.6	15.3 ± 5.6	0.9 ± 0.4	4.3 ± 2.0	22
Gender								
Male	19.1 ± 3.5	5.1 ± 2.3	1.9 ± 1.2	9.4 ± 2.1	7.7 ± 2.2	2.6 ± 1.0	12.6 ± 2.6	63
Female	24.8 ± 5.2	7.4 ± 4.1	2.7 ± 1.7	10.6 ± 3.2	2.1 ± 1.0	0.6 ± 0.4	11.1 ± 3.0	31
Age								
Juvenile	19.5 ± 7.3	13.1 ± 6.0	2.2 ± 2.2	12.1 ± 4.9	2.7 ± 1.5	1.1 ± 0.8	15.6 ± 5.2	20
Mature	17.7 ± 1.0	6.6 ± 0.9	1.1 ± 0.2	7.2 ± 0.6	2.2 ± 0.3	0.6 ± 0.1	21.8 ± 0.9	26

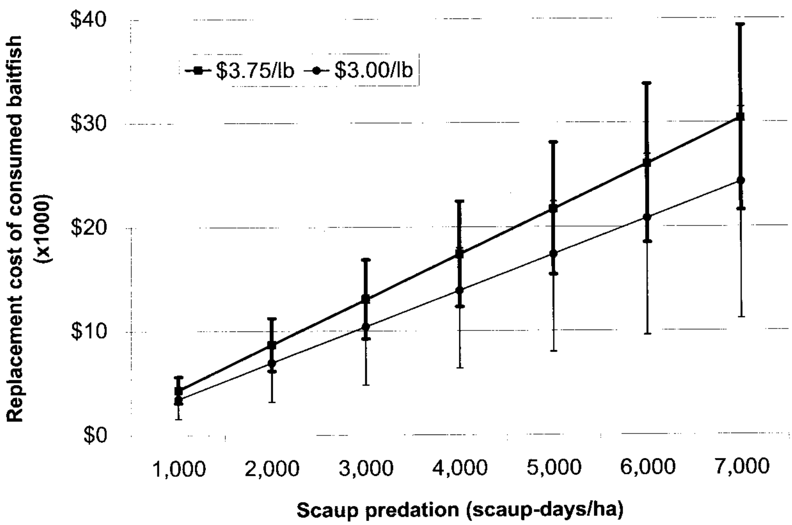

FIGURE 3. *Estimated replacement cost (± SEM) of baitfish consumed by lesser scaup at Arkansas baitfish aquaculture facilities at relatively high and low baitfish market values.*

tained fish biomass; and 3) the relative contribution of cyprinid fishes, invertebrates, and plant material to the net energy needed to maintain adult scaup. Baitfish farmers in central Arkansas experience diving ducks at their farms from November though March each year (Werner and Wooten 1999). Most (> 75%) diving ducks observed at baitfish farms (average size = 202 ha) during the present study were lesser scaup.

Among samples that contained a particular prey item, the average mass of fish, invertebrates, and plant material was 2.27 g, 5.54 g, and 0.46 g, respectively. We estimated the energy density of cyprinid fishes as 1.33 kcal/g (wet mass; Hartman and Brandt 1995) based on the dry matter content of minnows (26%; Cui and Wootton 1988). The fresh-mass energy density of invertebrates and plant material was estimated as 0.91 kcal/g and 0.57 kcal/g, respectively (Stiven 1961). We estimated the average energy content of recovered prey items as the product of average mass and energy density of these items (Σ = 8.32 kcal).

Based on the mass of birds in our study and their observed diet, lesser scaup should replenish observed gut contents an average of 10.8 times per day to procure the net energy needed for their maintenance ($NE_m \sim 90$ kcal = 111.5*kg body weight$^{0.75}$; Sugden and Harris 1972). Thus, lesser scaup may consume approximately 32.61 kcal (24.5 ± 7.2 g) of minnows/duck per d (i.e., the product of average fish mass in samples, energy density of cyprinids, and frequency of gut replenishment). Assuming: 1) that ducks occupy a particular farm each day from November through March (150 d), and 2) that 10.6% of these ducks consume baitfish, the replacement cost (Fig. 3) of consumed baitfish at 1,050 scaup-days/ha on a 200-ha farm (1,400 scaup present, or 150 scaup consuming baitfish) would be $3,610 and $4,515 at relatively low ($3/lb) and high ($3.75/lb; H. Thomforde, University of Arkansas-Pine Bluff, personal communication) baitfish market values, respectively. These costs would be $23,990 and $29,990, respectively, at 6,975 scaup-days/ha on a 200-ha farm (9,300 scaup present, or 985 scaup consuming baitfish; Fig. 3).

Discussion

We did not observe a predominance of baitfish in stomachs of lesser scaup collected at Arkansas baitfish farms. In contrast to previous observations regarding the biomass of golden shiners (approximately 7 g, $N = 20$) and goldfish (approximately 15 g, $N = 20$) within the esophagus and gizzard of lesser scaup collected at Arkansas baitfish facilities (Philipp and Hoy 1997), we recovered an average of 2.3 g of fish from ten scaup that contained fish biomass. In contrast to most studies that have not observed piscivory among scaup, however, our observations of lesser scaup diet composition were similar to those reported by Philipp and Hoy (1997; crustaceans, minnows, gastropods, insects, vegetation). Among ducks in the present study that contained at least one prey item, approximately 28% (24 of 86 scaup) contained fish remains. This observation is comparable to that of Philipp and Hoy (1997; 45 of 161 scaup, or 28%).

Our estimates of economic impacts were conservatively derived (i.e., assuming 10.6% of scaup at baitfish farms consume baitfish). Subsequent studies regarding the rate of fish biomass digestion and otolith erosion in fish-eating birds will enhance the reliability of these economic predictions. Whereas the activity and availability of aquatic invertebrates influence the foraging behavior of dabbling and diving ducks (Swanson 1977; Sjoberg and Danell 1982), additional research is needed to evaluate the availability and selection of non-fish prey items in relation to baitfish consumption by diving ducks at aquaculture facilities.

Given the relative stability (e.g., baitfish density through time, chironomid presence throughout study area) in the availability of prey items recorded in this study, observed differences in diet composition among collection periods may be attributable to dynamic nutrient requirements of wintering scaup subsequent and prior to their autumn and spring migrations, respectively. Few differences, however, existed between the diets of male and female, and juvenile and mature lesser scaup during the breeding season (Afton and Hier 1991), summer (Bartonek and Murdy 1970), migration (Afton et al. 1991), and winter (this study, Afton et al. 1991).

The cost of efficient damage management strategies should not exceed the replacement cost of marketable baitfish lost to predation. Thus, estimates of baitfish mortality (i.e., unmarketable fish in the absence of predation) will enable aquaculture producers to reliably apply thresholds of avian depredation when making management decisions. Moreover, effective predictions regarding wildlife impacts are dependent upon the reliability of abundance estimates throughout the period of depredation. Philipp and Hoy (1997) suggested that unusually large numbers of diving ducks were observed at Arkansas baitfish farms during the winters of 1994–1995 and 1995–1996. These authors also suggested that flocks of 200–1,000 diving ducks are commonly found around baitfish facilities, and as many as 2,000 diving ducks may inhabit a baitfish facility during the spring and fall migration (Philipp and Hoy 1997). Current depredation thresholds and seasonal estimates of fish-eating bird abundance will enable aquaculture producers to determine the cost-effectiveness of their damage management practices.

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